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Asbestos in talc powders and soapstone – the present state

Abstract

Talc powder and soapstone may contain asbestos. Random samples taken in the course of the past ten years from materials in use in Germany revealed only low asbestos contents. The present paper is based on analyses of bulk sample carried out by the German Berufsgenossenschaften as part of their prevention activities. In about one quarter of the 57 talc powder samples and 35 soapstone samples analysed by the BG-Institute for Occupational Safety and Health (BGIA), asbestos could be detected, albeit in low concentrations. Two samples of each talc and soapstone samples contained asbestos in quantities exceeding 0.1 weight %. Workplace measurements showed that use of talc powders containing no more than 0.1 weight % of asbestos resulted in asbestos fibre concentrations ranging at about 10,000 fibres/m³. Asbestos fibres could only be identified in five out of 68 workplace air samples, taken in 39 measurement series. The asbestos content and the exposition situation at the workplace are to be determined in accordance to the German Technical Rule for hazardous substances (TRGS) 517.

1 Introduction

Whether and to what extent asbestos can be found in talcum powders and soapstone has been a matter of repeated debate for decades. So far, however, there have not been any comprehensive systematic investigations. Until now, sample analysis has been mostly random and on a limited number of samples in each case. In 2000, for example, there was public controversy about the use of soapstone in schools. The results of investigations by the statutory accident insurance institutions on soapstone samples, which are presented in the following, led to the prohibition of the use of soapstone in educational establishments in most German Länder. Random samples of talcum powders have also been analysed for asbestos in the course of the statutory accident insurance institutions' preventive OSH work.

2 Legal situation

According to Appendix IV, No. 1, of the German Hazardous Substances Ordinance (Gefahrstoffverordnung –GefStoffV) [1], mineral raw materials, which also include talcum powders and soapstone, may only be produced or used as long as their asbestos content by weight does not exceed 0.1%. This provision relates to extraction, preparation, further processing and re-use. The ban on exposure in existence until 2004 has been dropped in the new version of the GefStoffV. If asbestos fibres are released or release is possible during activities with mineral raw materials, protection class 4 measures have to be taken as a result of asbestos' classification as a K1 substance (Arts. 8 to 11, GefStoffV). Also applicable are the supplementary provisions for protection from asbestos-related risks in accordance with Appendix III, No. 2.4, as long this does not involve activities causing only low exposure. To implement these provisions of the ordinance, the Hazardous Substances Committee (Ausschuss für Gefahrstoffe, AGS) enforced its Technical Rule for Hazardous Substances (Technische Regel für Gefahrstoffe, TRGS) 517 "Activities with potentially asbestos-containing raw materials and with preparations and products made from them" [2]. This TRGS applies comprehensively to the handling of a wide variety of mineral raw materials in a wide range of sectors and fields of application. This rule defines the concept of asbestos in relation to mineral raw materials with greater precision. It lays down an investigation strategy in the course of risk assessment under GefStoffV and contains for the first time binding analytical methods for determining the asbestos content by weight in mineral raw materials, preparations and products, and describes general protective measures and, in relation to the respective field of application, special protective measures that must be observed in addition.

To detect asbestos in talcum powder, analytical method No. 1, a long-established SEM-EDXA method as given in Appendix 2 of TRGS 517, must be applied [3]. For this the powder, immediately after suspension on a gold coated capillary-pore membrane filter, is analysed by scanning electron microscopy for asbestos fibres that fulfil the WHO dimensions (length > 5 µm, diameter < 3 µm, length/diameter ratio > 3 : 1). The supplementary criteria for the identification of asbestos by EDXA are to be applied in accordance with [4]. The weight content of asbestos is calculated from the fibre dimensions. This method's detection limit is estimated to be 0.008% by weight. It should nevertheless be borne in mind that far lower asbestos weight contents can be determined in individual cases[1]. In addition, the number of asbestos fibres per mg of analysed material ascertained with this method must be quoted so that the potential for asbestos fibre exposure can be estimated.

The weight content of asbestos in soapstone has to be determined with method No. 4 of Appendix 2 of TRGS 517. It is largely identical to the method described above. However, the sample of soapstone undergoing analysis is comminuted beforehand by grinding. Concerning a possible asbestos exposure, this method represents the worst case in terms of the mechanical processing of compact materials (e.g. by drilling, milling and grinding).

The application of the analytical methods as given in Appendix 2 of TRGS 517 is useful for determining whether a material of mineral origin satisfies the requirements of Appendix IV, No. 1, GefStoffV, i.e. has an asbestos content of not more than 0.1% by weight.

If it is discovered in studies in accordance with section 3 of TRGS 517 that the investigated material does contain asbestos, the general protection measures quoted in Section 4 of TRGS must be taken. In addition to these, special protection measures are given in Section 5 for specific applications. For instance, for the use of talcum powder as a release agent and lubricant, Section 5.4 lists special measures for storage and materials handling, its use in the working environment and the cleaning of industrial equipment. The processing of soapstone calls for observance of the special measures of Section 5.3 (processing of natural stone) for the cleaning of surfaces, mechanical processing, and the cleaning of the working environment.

3 Asbestos and cleavage fragment asbestos fibres

If the asbestos fibres arising during activities with mineral raw materials such as chippings, talc or soapstone are compared to those arising during the processing or demolition of industrial products containing asbestos (asbestos cement, seals, cords etc.), the difference is striking. The fibres of

[1] An estimated value is given, as a generally applicable detection limit cannot be defined. The reason for this is that the detection limit of the number concentration of asbestos fibres on the investigated filter is calculated by means of Poisson statistics. The weight of the fibres not present can only be estimated, however. Since the asbestos fibres in mineral raw materials can have very different dimensions and hence weights, which can differ by a factor of 100, only an estimated weight can be assumed based on empirical values. The estimated detection limit quoted must thus be treated as a rough guide.

industrially used asbestos liberated during mechanical processing mostly have a length/diameter ratio of > 10 : 1, the diameter of the fibres being in most cases less than 1 µm. The fibres released during the processing of the mineral raw materials occurring and used in Germany, on the other hand, are typically relatively short and fat. To illustrate this phenomenon, *Rödelsperger* et al*.* compared the length/diameter ratio (L : D) of asbestos fibres from the site of an asbestos removal enterprise (73% of all respirable fibres with an L : D > 10 : 1) with that of asbestos fibres arising during the processing of gabbro in a quarry (3% of all respirable fibres with an L : D > 10 : 1) [5]. The asbestos fibres from mineral raw materials are not usually contained in a fibrous form in the raw material but arise for the most part only after mechanical processing (cleavage fragmentation) of the in most cases rod- to needle-like and even granular crystals of the asbestos mineral. Asbestos fibres of this kind would be more appropriately described as cleavage fragments. **Figure 1** presents a comparison of these two types of asbestos fibres.

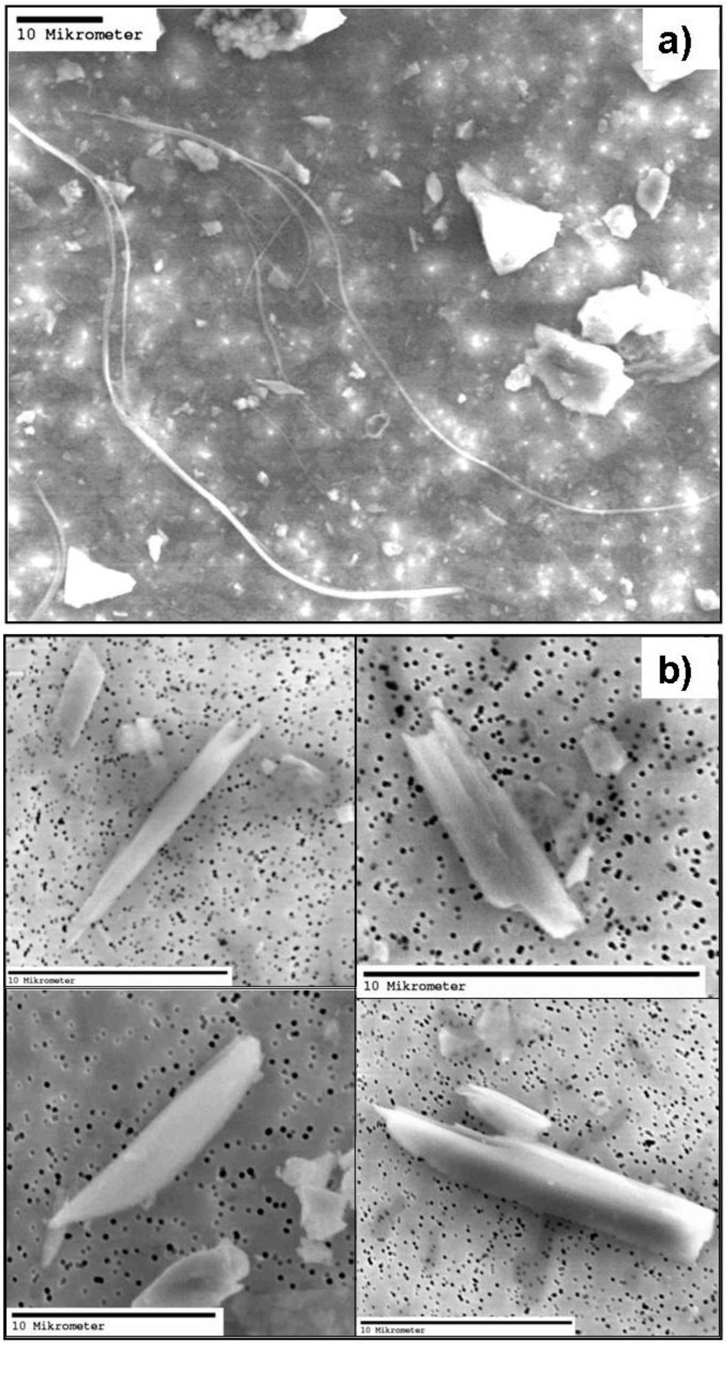

Figure 1:
Scanning electron microscopic images of asbestos fibres (length of scale bar 10 µm in each case).
a) chrysotile fibres from a ground asbestos cement product
b) cleavage fragment asbestos fibres (amphibole) with the WHO dimensions of respirable fibres from a talcum powder

To take account of this particular circumstance, TRGS 517 contains definitions that go beyond the definition of asbestos in GefStoffV:

"2.3 Weight content of asbestos

The weight content of asbestos under the terms of TRGS 517 is not necessarily identical to the weight share of asbestos minerals, as it is only as a result of mechanical size reduction that it becomes apparent to what extent asbestos fibres arise from asbestos minerals. The weight content can therefore change as a result of further treatment or processing. Decisive for the determination of the weight content of asbestos are the evaluation rules of the analytical methods described in Appendix 2, Parts 1 to 4.

2.4 Asbestos fibres

Defined as asbestos fibres are those fibres which can be assigned on the basis of their chemical composition to the six asbestos minerals and which have the dimensions defined by the WHO (length > 5 µm, diameter < 3 µm, length/diameter ratio > 3 : 1). It makes no difference whether an asbestos fibre is released from a fibrous or non-fibrous mineral source. In analysis, it is not usually possible to make a reliable distinction on the basis of a single particle."

In cases where asbestos is detected at all, either in talcum powders or soapstone, these are mostly amphibole particles. Their habit suggests that they also have arisen for the most part by mechanical size reduction and must be termed cleavage fragment asbestos fibres (see Figure 1).

Cleavage fragment fibres are distinctive not only of asbestos, but also arise in other sectors due to the mechanical treatment of different materials. Because of the striking morphological differences between "true" and cleavage fragment fibres, there has been growing interest in the last few years in how to proceed in the classification and assessment of cleavage fragment fibres [5 to 7].

4 Asbestos in talcum powder

Depending on the mineral deposit, the composition of talcum powders can vary a great deal. Some talcum powders on the market contain over 95% of the mineral talc, a phyllosilicate. Also available are powders containing only a small proportion of talc. Typical other mineral ingredients of talcum powders are chlorites, serpentine, olivine, haematite, magnesite, dolomite and calcite. Nevertheless, a large proportion of the talcum powders marketed in Europe consist mainly of talc. In some cases, shares of amphibole minerals of the order of up to a few % by weight can also be observed. These amphiboles are often tremolite or actinolite, and more rarely anthophyllite as well. Often these asbestos minerals are not fibrous. Scanning electron microscopic analyses of such talcum powders show that the amphibole particles in most cases do not have the dimensions of respirable fibres. The weight content of amphibole minerals is therefore not equal to the weight content of asbestos in talcum powder.

A fine example illustrating the discrepancy between the weight content of an asbestos mineral in talcum powder and the content of respirable asbestos fibres is that of the repeat analysis of a sample of a Chinese talcum powder dating back to 1993. In 1993, a tremolite content of 7% by weight was ascertained in the powder by X-ray diffraction. In a recent SEM-EDX analysis (method 1 according to TRGS 517), on the other hand, a weight content of 0.084% of respirable tremolite fibres was measured, which amounts to an asbestos fibre concentration of around 29,000 F/mg.

It is possible to estimate the asbestos contents of talcum powders currently available on the German market by evaluating the selected talcum powders randomly sampled by the OSH services of the statutory accident insurance institutions over the last few years. At the BG Institute for Occupational Safety and Health (BGIA), a total of 57 talcum powders were analysed from 1996 to 2005 – in some cases double analyses of a single talcum powder at two different times. The purpose of the analyses was to identify whether asbestos fibre exposure can occur. The analytical method described above was applied with an estimated detection limit of 0.008% by weight [3]. Asbestos fibres were detected in 13 of the 57 samples. In ten of these samples, the weight content of asbestos ranged from 0.001 to 0.073%. In one talcum powder analysed on two occasions, weight contents of 0.18 and 0.19% respectively were found. For one of the samples, no weight content measurement was carried out (6,100 fibres/mg of the talcum powder of this sample). For the 13 samples the number of asbestos fibres found per mg of talcum powder ranged from about 800 to 53,000 F/mg[2]. **Figure 2** shows the asbestos weight contents and asbestos fibre concentrations in the powder for the samples containing asbestos.

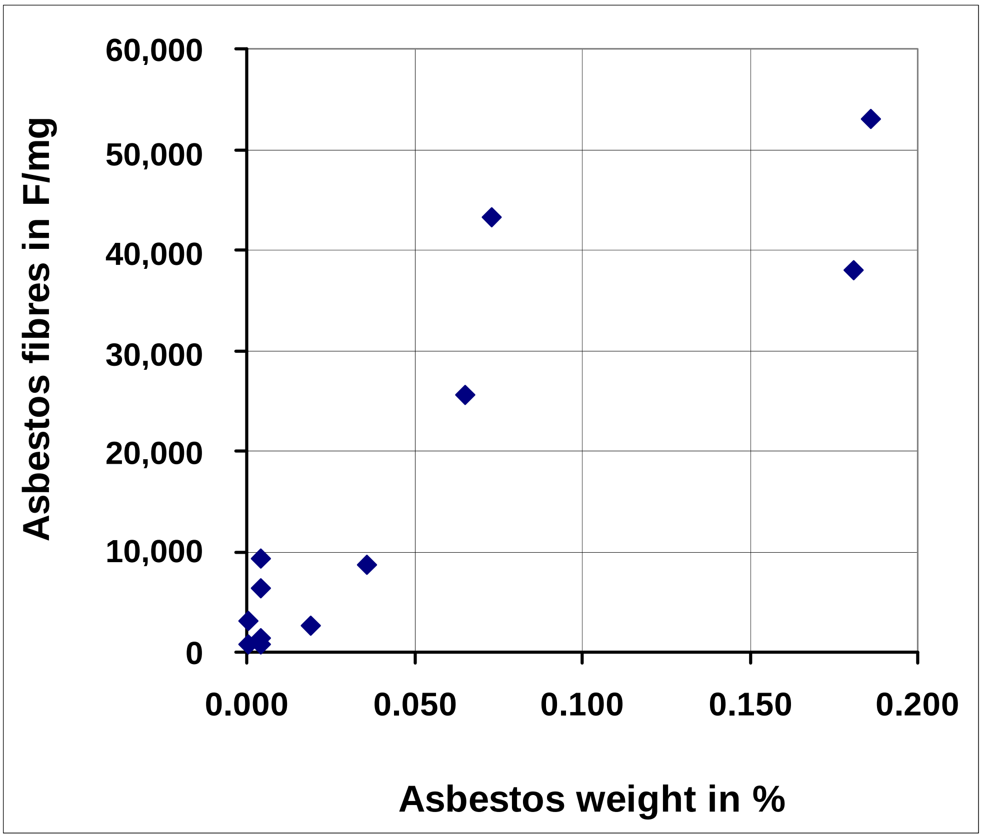

Figure 2: **Number of asbestos fibres per mg of talcum powder and asbestos weight content of twelve talcum powder samples in which asbestos was detected (for explanations see text).**

It can be confirmed that a large portion of the asbestos fibres contained in the samples belong morphologically to the group of cleavage fragment asbestos fibres. **Figures 3** and **4** show the L : D distribution of the asbestos fibres found in the four talcum powders with the highest fibre concentration values. Compared to this is the L : D distribution of a sample of ground synthetic asbestos cement. The share of long and thin fibres among the respirable asbestos fibres found overall in the talcum powders is much lower than in the ground sample of asbestos cement. The share of asbestos fibres with a diameter < 1 µm is 62% for the asbestos cement sample, while the share of fibres with diameters < 0.5 µm is still 20%. In the investigated talcum samples – based on a total of 55 fibres from four samples – these shares are only 31 and 2% respectively (see Figure 3).

However, Figures 3 and 4 also show that the dividing line between industrially used (long and thin) and cleavage fragment asbestos fibres is blurred. To illustrate the distinction, Figure 1 shows only unambiguous examples of fibres of both groups. Many particles are difficult to assign clearly to one of the two groups. If such a distinction is necessary, either statistical parameters or clearly defined criteria for differentiation would have to be specified for analytical evaluation.

To identify asbestos fibre exposure during activities with talcum powder, the statutory accident insurance institutions have also carried out measurements in firms. Available for evaluation are a total of 39 series of measurements dating from 1991 to 2005 with 68 air samples where the handling of talcum powders is documented for the working environment in which the samples were taken.

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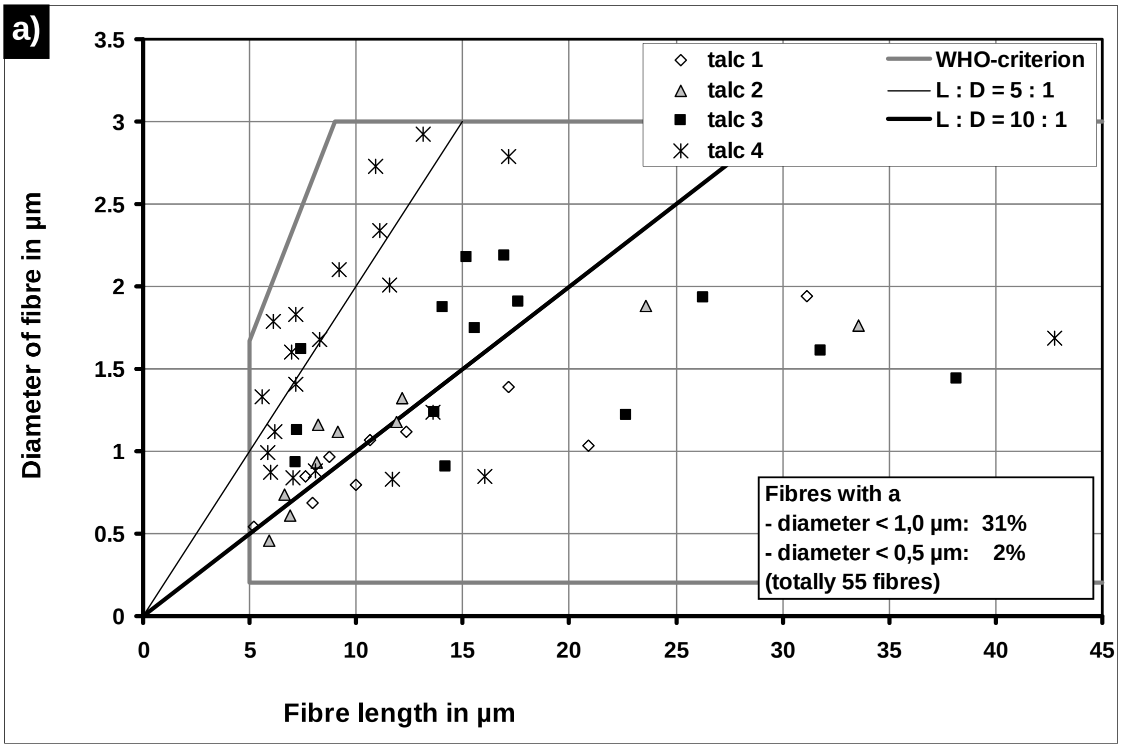
[2] The detection limit for the determination of the asbestos fibre count per mg of talcum powder ranges from 5,000 to 10,000 F/mg in the investigated samples (concentration with three found fibres).

Asbestos fibre concentrations were measured in only five of the 68 samples. The values range from 5,800 to 11,700 F/m³.



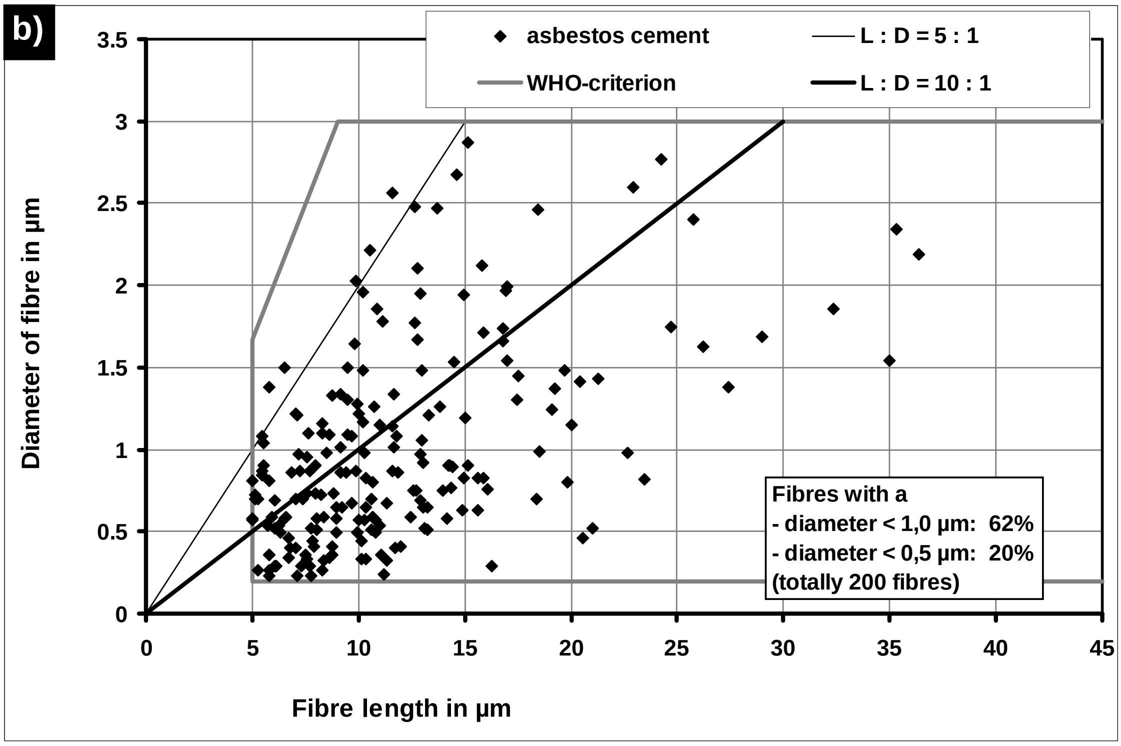


Figure 3: Length and diameter distribution of respirable asbestos fibres from material samples (analysis by SEM-EDXA as defined in [3]; compare Figure 4).
a) four talcum powder samples
(sample 1: 10 fibres; sample 2: 10 fibres; sample 3: 14 fibres; sample 4: 21 fibres);
b) ground asbestos cement

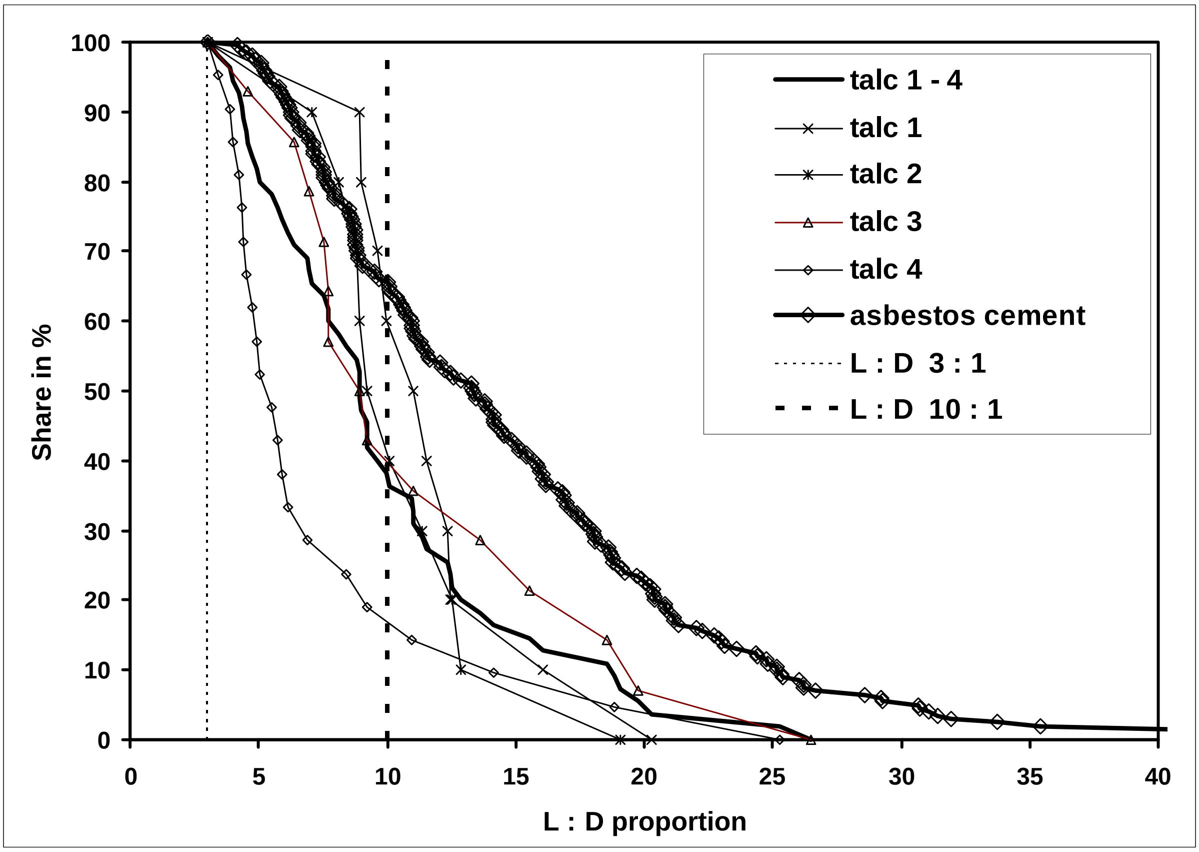


Figure 4: **Cumulative frequency of L:D ratios of respirable asbestos fibres in four talcum powder samples and ground asbestos cement (analysis by SEM-EDXA as defined in [3]; for number of asbestos fibres found in the samples, see Figure 3).**

In the remaining 63 samples, no asbestos fibres were detected. If asbestos exposure equal to half the detection limit were assumed for these samples, this would yield a fibre concentration of 8,800 F/m³ for the 50% exposure value and a fibre concentration of about 32,000 F/m³ for the 90% exposure value. The high 90% value can be attributed to the very short sampling time for some of the samples. If only the samples with a measurement duration > 1 h are referred to for this assumed asbestos fibre exposure equal to half the detection limit (resulting in 40 samples), this yields a 50% value of 8,600 F/m³ and a 90% value of 8,900 F/m³. It must be stressed that these are fictitious measurement results calculated from the detection limits and not based on actually found asbestos fibres.

5 Asbestos in soapstone

Soapstone is a naturally occurring mineral resource. It is a compact rock consisting in most cases primarily of the phyllosilicate talc. While displaying low hardness, it also features high temperature stability, a high heat storage capacity and insensitivity to temperature fluctuations. This is why soapstone is used, on the one hand, as an easy-to-work material for art or craft lessons and, on the other, as a construction material for stoves. Other applications include insulating compounds in the electroceramics industry, floor slabs, refractory mouldings and blocks for the construction of electrical heating apparatus and furnaces. Ceramic materials are usually produced by firing soapstone at temperatures of 1,300 to 1,400°C and are then usually known as steatite. However, this term is not uniformly used, since unfired soapstone is sometimes called steatite as well. Soapstone is nevertheless not pure talc rock, but consists of a blend of different minerals depending on the geological conditions of the particular deposit. Typical soapstone contains not only talc, but also significant portions of chlorite. It may also contain portions of magnesite and serpentine. Amphiboles, quartz, calcite, mica and a number of other minerals may also occur in traces or small proportions.

Chrysotile and/or the types of amphibole asbestos tremolite, actinolite or anthophyllite can also arise in soapstone. While chrysotile always has a fibrous structure, the amphibole minerals contained in soapstone are mostly prismatic or rod-like in structure. These are thus in most cases cleavage fragment asbestos fibres (see above). Since it is only the respirable asbestos fibres that pose a health threat, a dust-free handpiece or moulding of soapstone is not a source of risk. The normal use of a soapstone stove or furnace does not pose a risk in this respect either. Only when soapstone is processed, e.g. by sawing, drilling or grinding, dust is generated. Asbestos fibres may then be released – provided the rock from the deposit in question actually contains asbestos minerals. In ceramic workpieces made of fired soapstone, no (more) asbestos is contained because of the high firing temperatures.

In the course of the debate on the use of soapstone in schools in 2000, the statutory accident insurance institutions selected a total of 35 material samples in 2001 and 2002 and investigated them for asbestos at the BGIA. An attempt was made here to cover as representative a cross section as possible of widely used soapstone types. Soapstone samples from Brazil, China, Germany, Finland, India and Norway were analysed, these being not only soapstone for schools or art purposes but also samples from the construction sector (stoves). The samples were selected for their relevance, i.e. where possible random samples were taken from the most frequently used soapstone types. The samples were prepared and analysed along the lines of method 4 in TRGS 517 [2] (see above). Asbestos fibres were found in nine of the 35 samples, these being anthophyllite in each case. In two of the nine samples, tremolite fibres were detected as well (only one fibre in each case). For the nine samples, the asbestos fibre concentration per mg of ground soapstone ranged from about 1,500 and 70,000 F/mg. The asbestos weight contents were not calculated for all samples. For the sample with a concentration of 70,000 F/mg, an asbestos weight content of about 0.2% was calculated.

The similarity between talc and anthophyllite fibres proved to be a major stumbling block in the identification of asbestos. In some cases, it was not possible to classify the individual fibres as talc or anthophyllite fibres by EDX analysis. Since the ranges of possible chemical compositions of the two fibre types overlap due to the imprecision of EDX analysis, supplementary tests were undertaken with transmission electron microscopy. These revealed that certain samples contained both talc and anthophyllite fibres with almost identical chemical compositions.

6 Conclusions

It can be basically concluded that no global statements can be made about whether talcum powders or soapstone contain asbestos. The analyses conducted as examples show that in many cases the established SEM-EDX analytical methods did not find asbestos in either talcum powders or soapstone. However, in about one in four of the samples of both soapstone and talcum analysed in the last few years in the course of the statutory accident insurance institutions' OSH work, extremely small shares of asbestos were found. Two of the 57 talcum powders and two of the 35 soapstone samples had asbestos contents that are prohibited under Annex IV, No. 1, GefStoffV (Hazardous Substances Ordinance).

Measurements of the asbestos fibre concentrations in working environments involving talcum powders showed that where talcum powders with low asbestos weight contents (< 0.1%) were employed, asbestos fibre exposure up to the order of about 10,000 F/m^3 can occur.

It is essential to request sellers of talcum powders and soapstone to furnish proof from a qualified body that no asbestos can be detected in the material with the specified analytical methods (according to Appendix 2 of TRGS 517).

Even if no asbestos can be detected, protective measures must always be taken when talcum powders are used and soapstone is processed. The minimum standards are described in the Technical Rule for Hazardous Substances 500 "Protective measures" [8]. This applies as much to the use of soapstone in schools or medical treatment centres as to industrial uses

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